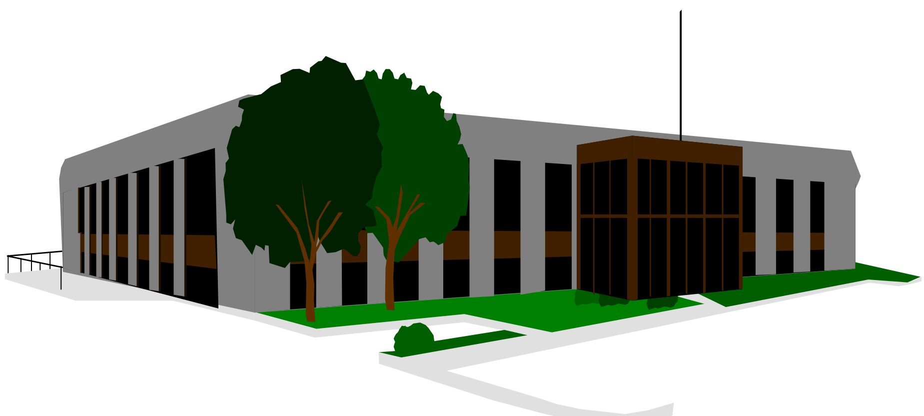
INDOOR AIR QUALITY ASSESSMENT

Lunenburg High School
1079 Massachusetts Avenue
Lunenburg, Massachusetts



Prepared by:
Massachusetts Department of Public Health
Bureau of Environmental Health Assessment
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Background/Introduction

At the request of John Londa, Director of Facilities and Grounds for the Lunenburg School Department, the Massachusetts Department of Public Health (MDPH), Bureau of Environmental Health Assessment (BEHA) provided assistance and consultation regarding indoor air quality at the Lunenburg High School, 1079 Massachusetts Avenue, Lunenburg, Massachusetts.

On May 3, 2001, a visit was made to this school by Michael Feeney, Chief of Emergency Response/Indoor Air Quality (ER/IAQ), BEHA, to conduct an indoor air quality assessment. Mr. Feeney was accompanied by Mr. Londa during the assessment.

The school is a brick building constructed between 1955 and 1957. A greenhouse was constructed within the school courtyard in 1979. The school is built into a hill so that the majority of the school is on a main floor with a ground floor built under one wing. General classrooms, library, school nurse, computer room, cafeteria, kitchen, auditorium, gymnasium, art rooms and office space are located on the main floor. The courtyard is also on this level. The ground floor contains science classrooms, chemical storage, a graphics lab and a woodshop.

Methods

Air tests for carbon monoxide, carbon dioxide, temperature and relative humidity were taken with the TSI, Q-Trak, IAQ Monitor, Model 8551.

Results

The school houses grades 9-12 and has a student population of approximately 550 and a staff of approximately 70. The tests were taken during normal operations at the school. Test results appear in Tables 1-5.

Discussion

Ventilation

It can be seen from the tables that carbon dioxide levels were elevated above 800 parts per million of air (ppm) in ten out of forty-seven areas surveyed, indicating adequate fresh air ventilation in most areas tested. It is important to note however, that most classrooms had open windows and/or open doors during the assessment, which can greatly reduce carbon dioxide levels. Particular areas to note are the art rooms and classrooms 229 and 226, in which carbon dioxide levels were above 800 ppm even with open windows and doors.

Fresh air in classrooms is supplied by a unit ventilator (univent) system (see Figure 1). Univents draw air from outdoors through a fresh air intake located on the exterior walls of the building and return air through an air intake located at the base of each unit. The mixture of fresh and return air is drawn through a filter and heating coil, and is then expelled from the univent by motorized fans through fresh air diffusers. Univents were found turned off in some classrooms. Obstructions to airflow, such as papers and books stored on univents and bookcases, carts and desks in front of univent returns were seen in a number of classrooms. Some univents also contained accumulated dirt/debris. These univents should be cleaned before operating to prevent aerosolization of this material. In order for univents to provide fresh air as designed, intakes must remain free of obstructions. Importantly, the units must remain "on" and allowed to operate while these rooms are occupied.

Univent fresh air intakes in the enclosed courtyard and in some areas along the outer exterior wall are located within subterranean, cement-walled pits (see Picture 1). An accumulation of leaves and debris exist below a number of these fresh air intakes. Wet leaves can provide a medium for mold growth & odors that can be entrained into the building by the air handling equipment.

Exhaust ventilation in classrooms is provided by a mechanical system consisting of ducted, grated wall vents (see Picture 2). Exhaust ventilation was not operating in a number of areas during the assessment. Of note was room 246, which appeared to be backdrafting air into the classroom. Several exhaust vents were blocked by file cabinets or other items. In order for exhaust ventilation to function as designed, vents must be activated and remain free of obstructions.

Room 239 has been subdivided into two enclosed rooms. The univent is separated from the exhaust vent by floor to ceiling walls, which form 239A and 239B. This subdivision does not provide exhaust ventilation for 239A.

A combination of a timer system (see Picture 3) and thermostats control the ventilation system. The thermostats will deactivate univents once a predetermined temperature is achieved, called "cycling". Ventilation is activated once room temperature drops below a set level. When the room temperature exceeds the thermostat setting, ventilation deactivates. This periodic deactivation can result in little fresh air introduction into classrooms.

To maximize air exchange, the BEHA recommends that both supply and exhaust ventilation operate continuously during periods of school occupancy. In order to have proper ventilation with a univent and exhaust system, the systems must be balanced to provide an adequate amount of fresh air to the interior of a room while removing stale air from the room. According to school department officials, the date of the last balancing of these systems was not available at the time of the assessment. It is recommended that existing ventilation systems be re-balanced every five years to ensure adequate air systems function (SMACNA, 1994).

A number of areas are cooled using wall or window-mounted air conditioners (WMAC) (see Picture 4). Some air conditioners have the capacity to introduce fresh air, however the majority of installed machines recycle indoor air only.

The Massachusetts Building Code requires a minimum ventilation rate of 15 cubic feet per minute (cfm) per occupant of fresh outside air or have openable windows in each room (SBBRS, 1997; BOCA, 1993). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health

Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week, based on a time weighted average (OSHA, 1997).

The Department of Public Health uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches.

Temperature readings ranged from 70^{o} F to 85^{o} F, which were above the BEHA recommended comfort level in most (42) areas surveyed. The BEHA recommends that indoor air temperatures be maintained in a range between 70^{o} F to 78^{o} F in order to provide for the comfort of building occupants. It should be noted however, that the temperature outdoors on the day of the assessment was 92^{o} F. It is difficult to control temperature and maintain comfort without the ventilation equipment operating as designed. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply. Lack of ventilation can lead to poor indoor air quality and comfort complaints. While temperature readings outside the recommended range are generally not a health concern, increased temperature can affect the relative humidity in a building.

The relative humidity in the building was within or close to the BEHA recommended comfort range in most areas sampled. Relative humidity measurements ranged from 31 percent to 46 percent. The BEHA recommends that indoor air relative humidity is comfortable in a range of 40 to 60 percent. Of note is that relative humidity measured indoors exceeded outdoor measurements (range +6-21 percent). The increase in relative humidity can indicate that the exhaust system alone is not operating sufficiently to remove normal indoor air pollutants (e.g., water vapor from respiration). Moisture removal is important since the sensation of heat conditions increases as relative humidity increases. As indoor temperature rises, the addition of more relative humidity will make occupants feel hotter. If moisture is removed, the comfort of the individuals is increased. Removal of moisture from the air, however, can have some negative effects. Please note that relative humidity levels would be expected to drop during the heating season. The sensation of dryness and irritation is common in a low relative humidity environment. Low relative humidity is a very common problem during the heating season in the northeast part of the United States.

Microbial/Moisture Concerns

Plants were noted throughout the school. A number of classrooms have water damaged windowsills that appear to have resulted from over watering of plants (see Picture 5). In one room, large plants are located on wall-to-wall carpeting (see Picture 6). Plant soil and drip pans can serve as a source of mold growth. Plants should be located away from univents and exhaust ventilation to prevent aerosolization of dirt, pollen or mold.

Water damage was apparent around the sink of room 237. Repeated leakage or improper drainage/overflow can lead to water penetration of countertop wood, the cabinet interior and behind cabinets. Like other porous materials, if these materials become wet repeatedly they can provide a medium for mold growth.

Room 234 has two clothes dryers. One dryer is disconnected from its exhaust vent (see Picture 7). The second clothes dryer terminates into a plastic appliance with open sides (see Picture 8). This configuration can add water vapor into the area when the dryers operate, increasing relative humidity. In addition, dryer lint can become aerosolized and serve as a source of eye and respiratory irritation. Uncontrolled moisture sources can also wet building materials (e.g., wallboard, carpeting), which may result in mold growth. To avoid this occurrence, clothes dryers should be vented directly outdoors.

A fall out shelter exists in the ground floor near the core of the building (see Picture 9). This area does not have a ventilation system. BEHA staff detected a significant musty odor upon entering the fall out shelter. The source of the odor appears to be the numerous paper, cardboard, cloth and other porous materials that were stored in the subterranean, unventilated space. Without dilution and/or removal by mechanical ventilation odors and moisture can build up in this area.

Shrubbery was noted in direct contact with the exterior wall brick or was in close proximity to univent fresh air intakes in several areas around the building (see Picture 10). Plants were growing directly against the building. Shrubbery can serve as a possible source of water impingement on the exterior curtain wall. Plants retain water and in some cases can work their way into mortar and brickwork causing cracks and fissures, which may subsequently lead to water penetration and possible mold growth.

The gymnasium had cracked block windows (see Picture 11). In addition, some WAC installations for the print shop had signs of water damage along seams (see Picture 12). Cracks in windows and spaces around WMAC installations can serve as pathways for water to penetrate into the interior of a building.

Within the central courtyard is a greenhouse. Also within this area is a compost heap (see Picture 13) in close proximity to a classroom fresh air intake. Compost heaps may be a source of odors as materials degrade, particularly if the piled materials are not turned regularly. As with shrubbery, compost heaps can be a source of odor, particulates and microbes that can be entrained by the univents in the courtyard.

Other Concerns

A number of other conditions were noted during the assessment, which can affect indoor air quality. The chemical storage area is contained in two rooms. The interior room contains a flammable storage cabinet that is used to store acids (see Picture 14). The interior of the cabinet is corroded from off-gassing acids. The corroding of the metal shelf supports can lead to the undermining of the structural integrity of the shelves. An accidental bump to the shelf could cause these shelves to fail, resulting in the breakage of the glass containers and subsequent opportunity for acid release into the chemical storage area. Under the observed condition of these shelves, it is highly recommended that stored containers be removed to prevent shelf failure. Acids should be stored in an acid resistant cabinet.

The chemistry classroom contains a chemical hood (see Picture 15). The exhaust duct above the chemical hood is connected to a duct that serves as the exhaust vent for the interior chemical store room (see Pictures 16 and 17). This configuration can allow chemical vapors and fumes to enter the chemical storeroom via this ductwork when the chemical hood is deactivated. In addition, this configuration compromises the fire integrity of the chemical hood duct. The chemical hood duct should exit the building directly without breaches to prevent both fire and chemical backdraft.

The outer room of the chemical storage area contains a flammable storage cabinet vented to the outdoors through the window system using PVC pipe (see Picture 18). The National Fire Prevention Association (NFPA) does not require venting in flammable storage cabinets. However, if venting is done, it must be vented directly outdoors and in a manner not to compromise the specific performance of the cabinet (NFPA, 1996). If air backflow from outdoors into the cabinet through the venting occurs, off-gassing chemicals can be forced from the flammable storage cabinet into the storeroom. Proper design of exhaust vents should prevent air backflow into the cabinet. The flammable storage cabinet also contained a metal turpentine container that was corroded, which can destroy the integrity of the container (see Picture 19). Several other conditions of improperly stored materials were also found in the science wing:

1. The storeroom had a substantial number of empty bottles that formerly contained chemicals stored on a shelf. None of the bottles were sealed with caps. Without caps chemical residue can be released from these containers. Each of these containers should be contained and disposed of in a manner consistent with Massachusetts hazardous waste disposal laws and regulations.
2. Several gas cylinders of carbon dioxide and helium were found stored in a cardboard box on a shelf (see Picture 17). Under both industry regulations and good chemical

storage practice standards, cylinders of compressed gas must be fixed to a wall or stand to prevent damage to cylinder valves by tipping (Rose, S. L., 1984). A damaged cylinder valve can cause an immediate and uncontrolled release of the cylinder contents and result in the cylinder becoming a projectile. These cylinders must be secured as soon as possible to prevent accidental release and injury.

3. Chemical stock bottles are reused to store other materials.
4. Shelves do not have guardrails to prevent accidental breaks of chemical containers.
5. A number of bottles labeled by chemical formula and not name were noted. Containers should be labeled with the chemical name of its content so an untrained person can identify the material in the case of an emergency.
6. A refrigerator used for storage of chemicals had storage containers imbedded in accumulated freezer frost (see Picture 20). Freezing of containers can result in cracking of plastic and release of stored chemicals into the refrigerator interior.

It is highly recommended that a thorough inventory of chemicals in the science department be done to assess chemical storage and disposal in an appropriate manner consistent with Massachusetts hazardous waste laws.

Each univent is outfitted with a filter that strains particulates from airflow. Filters were either undersized (see Picture 21) or were of a type that provide minimal filtration of airborne respirable dust. In this condition dust, dirt and other debris can then be re-aerosolized by the ventilation system. In order to decrease aerosolized particulates, disposable filters with an increased dust spot efficiency can be installed. The dust spot efficiency is the ability of a filter to remove particulates of a certain diameter from air passing through the filter. Filters that have been determined by ASHRAE to meet its standard for a dust spot efficiency of a minimum of 40 percent would be sufficient to reduce airborne particulates (Thornburg, D., 2000; MEHRC, 1997; ASHRAE, 1992). Note that increased filtration can reduce airflow produced by the unit due to increased resistance (called pressure drop). Prior to any increase of filtration, each univent should be evaluated by a ventilation engineer to ascertain whether they can maintain function with more efficient filters.

The print shop (graphics) has no local exhaust ventilation for printing presses (see Picture 22). Inks containing volatile organic compounds (VOCs) are used in this classroom without any local exhaust ventilation. VOCs can be irritating to the eyes, nose, throat, and respiratory systems. Products containing VOCs must be used with adequate exhaust ventilation to prevent exposure. A large number of containers of printing chemicals were found on tables. Flammable materials in schools should be stored in a flammables storage cabinet that meets design criteria set forth by the National Fire Prevention Association (NFPA, 1996).

Complaints related to vehicle exhaust infiltration were expressed to BEHA staff. Bus exhaust odor is reported to penetrate into the building in the morning and afternoon during student boarding/alighting. Idling buses in the parking lot near the school can result in vehicle exhaust entrainment by the mechanical ventilation system and open windows under certain weather conditions. This may, in turn, provide opportunities for exposure to combustion products such as carbon monoxide. At the time of the assessment no vehicle exhaust odors or measurable levels of carbon monoxide were detected within the school. M.G.L. chapter 90 section 16A prohibits the unnecessary operation of the engine of a motor vehicle for a foreseeable time in excess of five minutes

(MGL. 1986). In addition it is recommended that vehicle traffic and parking be a minimum of fifty feet from fresh air intakes or areas using openable windows (US DOE, unknown).

Three photocopiers are located in a room near the graphics classroom, in an area without local exhaust ventilation. Of note is that at least one photocopier uses a liquid toner (see Picture 23). This product contains petroleum solvent, which is a VOC. VOCs and ozone can be produced by photocopiers, particularly if the equipment is older and in frequent use. VOCs and ozone are respiratory irritants (Schmidt Etkin, D., 1992). It is recommended that local separate exhaust systems that do not recirculate into the general ventilation system be used (US DOE, unknown).

Several classrooms contained dry erase boards and dry erase markers. Materials such as dry erase markers and dry erase board cleaners may contain VOCs, (e.g., methyl isobutyl ketone, n-butyl acetate and butyl-cellusolve) (Sanford, 1999), which can be irritating to the eyes, nose and throat.

Conclusions/Recommendations

The conditions noted at the Lunenburg High School raise several indoor air quality issues. The combination of the design of the building, maintenance, work hygiene practices and the condition of stored materials in the building, present conditions that can adversely influence indoor air quality. For these reasons a two-phase approach is required, consisting of **short-term** measures to improve air quality and **long-term** measures that will require planning and resources to adequately address overall indoor air quality concerns. In view of the findings at the time of the visits, the following **short-term** recommendations are made:

1. Remove leaves and other debris from univent fresh air intake subterranean pits, clean & inspect periodically.
2. Disconnect the flammable storage cabinet from the PVC pipes and reseal the cabinet with its original bunghole caps.
3. Disconnect the vent attached to the chemical hood duct. Render the chemical hood duct airtight.
4. Repair backdrafting exhaust vents.
5. To maximize air exchange, the BEHA recommends that both supply and exhaust ventilation operate continuously during periods of school occupancy independent of classroom thermostat control.
6. Examine each univent for function. Survey classrooms for univent function to ascertain if an adequate air supply exists for each room. Operate fresh air supply univents while classrooms are occupied. Consider consulting a heating, ventilation and air conditioning (HVAC) engineer concerning the calibration of univent fresh air control dampers school-wide.
7. Remove all blockages from univents and exhaust vents.
8. Once both the fresh air supply and exhaust ventilation are functioning, the ventilation system should be balanced by an HVAC engineering firm.
9. For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, scrupulous cleaning practices should be adopted to

minimize common indoor air contaminants whose irritant effects can be enhanced when the relative humidity is low. Drinking water during the day can help ease some symptoms associated with a dry environment (throat and sinus irritations).

10. Move plants away from univents in classrooms. Examine drip pans for mold growth and disinfect areas of water leaks with an appropriate antimicrobial where necessary.
11. Remove/relocate compost pile from inner courtyard.
12. Remove plants from floor with wall-to-wall carpeting. Move plants away from univents in classrooms. Ensure plants have drip pans. Examine drip pans periodically for mold growth and disinfect with an appropriate antimicrobial where necessary. Consider reducing the number of plants in certain areas.
13. Obtain a flammables storage cabinet for the graphic arts program.
14. Vent clothes dryers directly outdoors.
15. Repair water damaged sink countertops.
16. Obtain an acid resistant cabinet for storage of acids.
17. Have a chemical inventory done in all storage areas and classrooms. Properly store flammable materials in a manner consistent with the local fire code. Discard hazardous materials or empty containers of hazardous materials in a manner consistent with environmental statutes and regulations. Label chemical containers with the chemical name of its contents. Follow proper procedures for storing and securing hazardous materials.
18. Examine the feasibility of installing disposable filters with an increased dust spot efficiency in univents. Prior to any increase of filtration, each univent should be

evaluated by a ventilation engineer as to whether it can maintain function with more efficient filters.

19. Cut shrubbery in a manner to maintain a space of 3 feet from univent fresh air intakes.
20. Examine the feasibility of moving buses away from the building. Instruct bus drivers to adhere to the anti-idling law.
21. Obtain Material Safety Data Sheets (MSDS) for chemicals from manufacturers or suppliers. Maintain these MSDS' and train individuals in the proper use, storage and protective measures for each material in a manner consistent with the Massachusetts Right-To-Know Law, M.G.L. c. 111F (MGL, 1983).
22. Install guard along edge of chemical storage area shelves.
23. Defrost refrigerator and remove chemical. If containers are damaged, dispose of chemicals in a manner consistent with Massachusetts hazardous waste laws and regulations.
24. Remove mold colonized materials from the fall out shelter. Disinfect non-porous surfaces with an appropriate antimicrobial.
25. Examine and repair WAC installations to prevent water penetration as needed.

Long Term Recommendations

1. Examine the feasibility of providing local exhaust ventilation for printing press machines and photocopying equipment in graphics classroom. If not feasible,

consider moving graphic arts to another room where local exhaust ventilation can be provided.

2. Consider replacing water damaged windowsill materials.
3. Examine the feasibility of replacing damaged gymnasium block windows.
4. Examine the feasibility of restoring exhaust ventilation for room 239.
5. Consider installing mechanical ventilation or local exhaust vent in shelter to circulate air and remove excess moisture and odors.

References

ASHRAE. 1992. Gravimetric and Dust-Spot Procedures for Testing Air-Cleaning Devices Used in General Ventilation for Removing Particulate Matter. American Society of Heating, Refrigeration and Air Conditioning Engineers. ANSI/ASHRAE 52.1-1992.

BOCA. , 1993. The BOCA National Mechanical Code/1993. 8th ed. Building Officials and Code Administrators International, Inc., Country Club Hill, IL. Section M-308.1.1.

MGL. 1983. Hazardous Substances Disclosure by Employers. Massachusetts General Laws. M.G.L. c. 111F.

MGL. 1986. Stopped motor vehicles; Operation of Engine; Time Limit; Penalty. Massachusetts General Laws. M.G.L. c. 90:16A.

MEHRC. 1997. Indoor Air Quality for HVAC Operators & Contractors Workbook. MidAtlantic Environmental Hygiene Resource Center, Philadelphia, PA.

NFPA. 1996. Flammable and Combustible Liquids Code. 1996 ed. National Fire Prevention Association, Quincy, MA. NFPA 30.

OSHA. 1997. Limits for Air Contaminants. Occupational Safety and Health Administration. Code of Federal Regulations. 29 C.F.R 1910.1000 Table Z-1-A.

Rose, S. L. 1984. Clinical Laboratory Safety. Van Nostrand Reinhold, New York, NY.

Sanford. 1999. Material Safety Data Sheet (MSDS No: 198-17). Expo® Dry Erase Markers Bullet, Chisel, and Ultra Fine Tip. Sanford Corporation. Bellwood, IL.

Schmidt Etkin, D. 1992. Office Furnishings/Equipment & IAQ Health Impacts, Prevention & Mitigation. Cutter Information Corporation, Indoor Air Quality Update, Arlington, MA.

SBBRS. 1997. Mechanical Ventilation. State Board of Building Regulations and Standards. Code of Massachusetts Regulations. 780 CMR 1209.0

SMACNA. 1994. HVAC Systems Commissioning Manual. 1st ed. Sheet Metal and Air Conditioning Contractors' National Association, Inc

Thornburg, D. 2000. Filter Selection: a Standard Solution. *Engineering Systems* 17:6 pp. 74-80.

US DOE. Unknown. School Design Guidelines for Hot, Dry Climates. US. Department of Energy, High Performance School Initiative, Washington, DC.

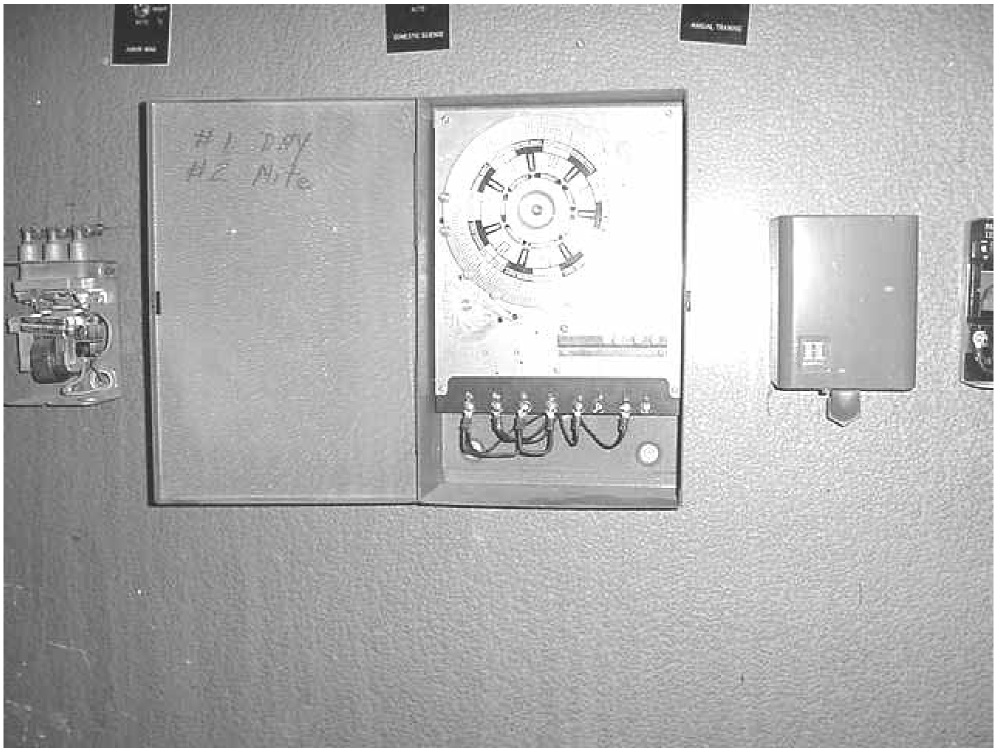
Picture 1

Univent Fresh Air Intake Located in Subterranean, Cement-Walled Pit

Picture 2

Exhaust Vent in Classroom

Picture 3



Ventilation System Timer

Picture 4

Wall Mounted Air Conditioner

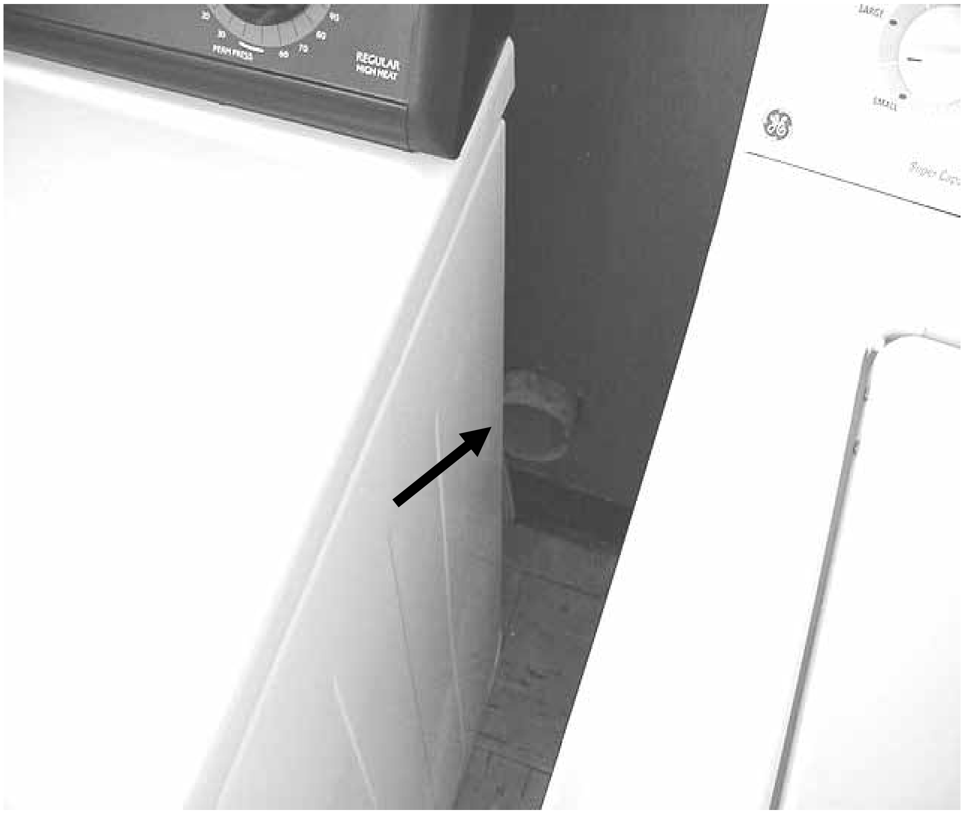
Picture 5

Water Damaged Window Sill That Appears To Have Resulted From Over Watering of Plants

Picture 6

Large Plants Located on Wall-To-Wall Carpeting

Picture 7

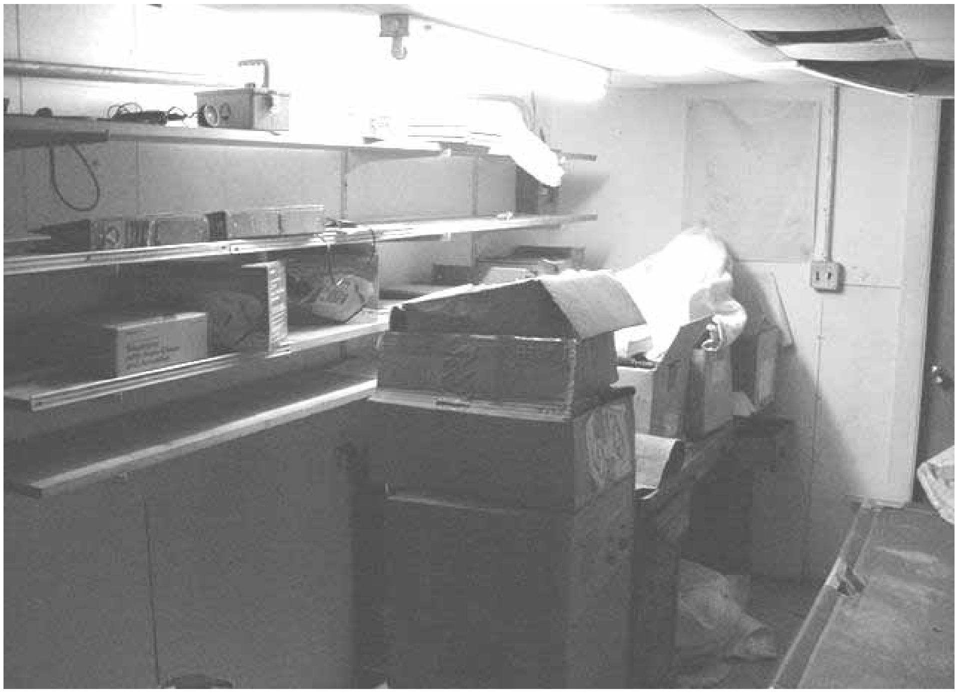


Dryer Disconnected From Its Exhaust Vent

Picture 8

Second Clothes Dryer Terminating into A Plastic Appliance with Open Sides

Picture 9



Fallout Shelter

Picture 10

Shrubbery in Direct Contact with the Exterior Wall Brick

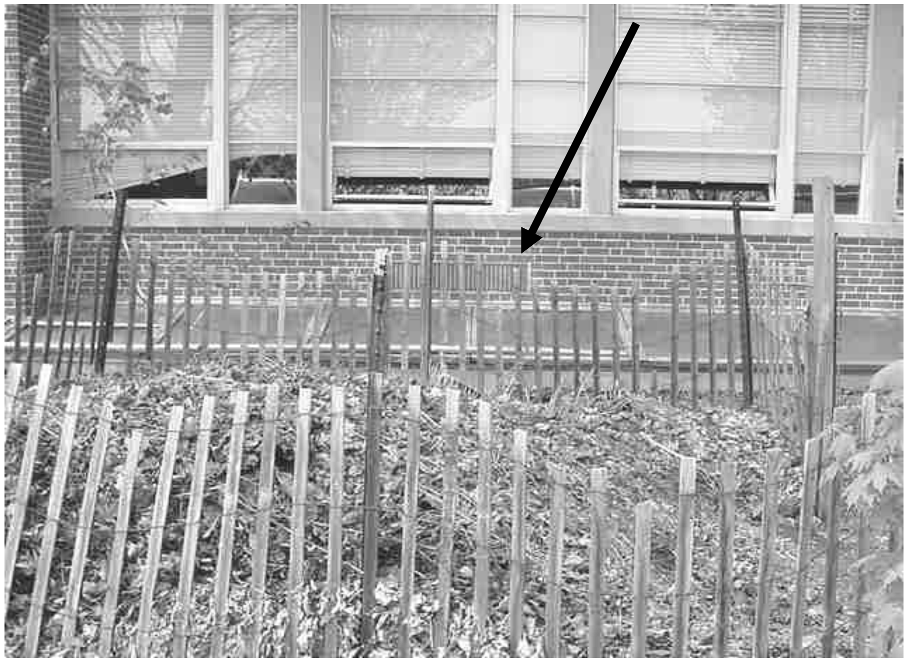
Picture 11

Cracked Block Windows in Gymnasium

Picture 12

WAC Installations for the Print Shop Show Signs of Water Damage along Seams

Picture 13

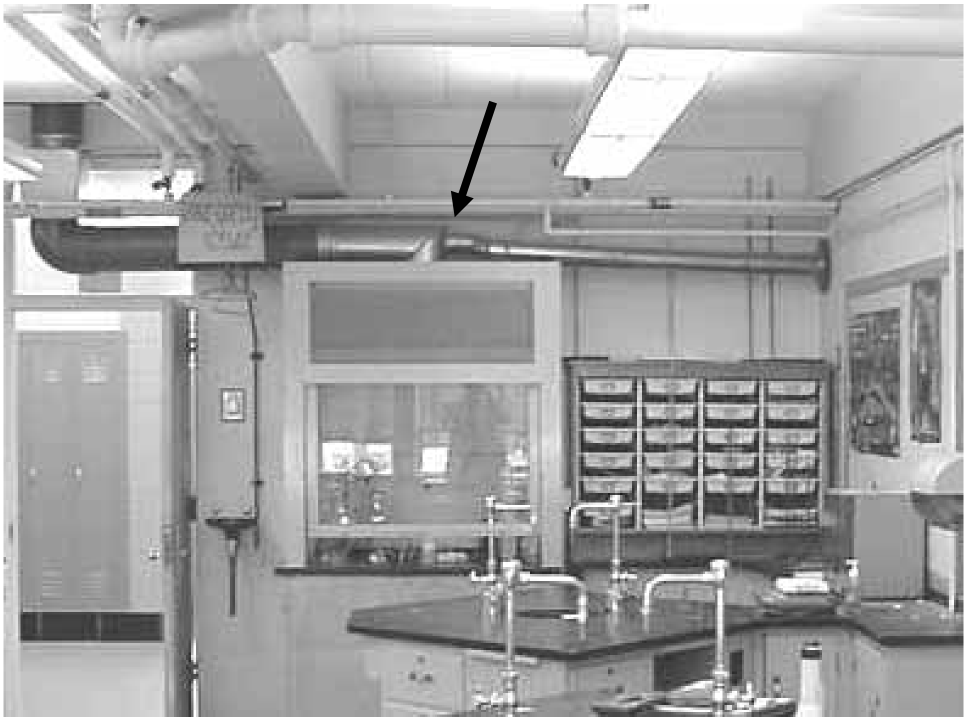


Compost Heap in Close Proximity to A Classroom Fresh Air Intake.

Picture 14

Flammable Storage Cabinet Used to Store Acids, Note Corrosion

Picture 15



Chemical Hood in the Chemistry Classroom, Note Duct Connection

Picture 16

Exhaust Duct for Chemical Hood Connected To Duct That Serves As the Exhaust Vent For The Interior Chemical Store Room

Picture 17

Exhaust Vent **Gas Cylinder**

Open Exhaust Vent for the Interior Chemical Storeroom, Note Gas Cylinder

Picture 18

Flammable Storage Cabinet Vented To the Outdoors Through the Window System Using PVC Pipe

Picture 19

Corroded Metal Turpentine Container

Picture 20

Storage Containers Imbedded In Accumulated Freezer Frost

Picture 21

Undersized Univent Filter, Note Space around Edge

Picture 22

General Ventilation Ductwork in Graphics Area,
No Local Exhaust Ventilation for Printing Presses

Picture 23

A Liquid Toner Photocopier

TABLE 1

Indoor Air Test Results – Lunenburg High School, Lunenburg, MA – May 3, 2001

Location	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation Intake	Ventilation Exhaust	Remarks
Outside (Background)	444	92	25					
Auditorium	587	81	33	0	Yes	Yes	Yes	Hole in wall
Gym	1280	81	44	40+	No	Yes	Yes	Broken window, door open
Gym Office	1167	79	42	2	No	Yes	No	Supply off, rubber odor, floor fan, door open
237	653	79	39	12	Yes	Yes	Yes	Supply and exhaust off, window and door open, several plants-on cardboard, water damaged sink
250	660	81	36	1	Yes	Yes	Yes	Exhaust off-blocked by file cabinet, supply blocked by books, window and door open, plants-on cardboard, floor fan
248	703	83	35	0	Yes	Yes	Yes	Supply off, exhaust blocked by cabinet, window open, 19 computers
247	742	82	35	19	Yes	Yes	Yes	Supply off, window open
246	720	82	35	0	Yes	Yes	Yes	Thermostat off, exhaust blowing air backwards after activation,

*** ppm = parts per million parts of air**
CT = ceiling tiles

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 2

Indoor Air Test Results – Lunenburg High School, Lunenburg, MA – May 3, 2001

Location	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation Intake	Ventilation Exhaust	Remarks
								window and door open
239A	546	81	33	2	Yes	Yes	No	Thermostat off, window open
239B	554	80	34	0	Yes	Yes	Yes	Exhaust blocked by desk, window open
240	532	79	34	1	Yes	Yes	Yes	Window open
244	818	80	36	18	Yes	Yes	Yes	Supply blocked by cardboard, door open
243	636	80	36	10	Yes	Yes	Yes	Window open
242	538	80	36	18	Yes	Yes	Yes	Window and door open
235	537	80	37	0	Yes	Yes	Yes	Exhaust off, window and door open, plants
236	531	80	36	6	Yes	Yes	Yes	Window and door open, plant/leaves near fresh air intake
Library	632	84	36	18	Yes	Yes	Yes	Window and door open, 2 floor fans
Library-Computer Room	527	85	34	2	Yes	Yes	No	Window and door open, 17 computers

*** ppm = parts per million parts of air**
CT = ceiling tiles

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 3

Indoor Air Test Results – Lunenburg High School, Lunenburg, MA – May 3, 2001

Location	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation Intake	Ventilation Exhaust	Remarks
208	505	84	32	4	Yes	Yes	Yes	Door open, floor fan
219	684	85	34	21	Yes	Yes	Yes	Supply and exhaust off, door open, floor fan
209	589	85	33	13	Yes	Yes	Yes	Window and door open, plants
217	688	85	33	16	Yes	Yes	Yes	Supply off, window and door open, white board
210	564	85	37	21	Yes	Yes	Yes	Window and door open, floor fans, white board
103	490	82	31	1	Yes	Yes	Yes	Bush outside air intake, door open
103 (Bio-prep)						No	Yes	Hole for shower pipe, door open
241	677	81	35	16	Yes	Yes	Yes	Window open, plants
228	706	81	35	16	Yes	Yes	Yes	Exhaust off, window and door open, white board
227	661	80	35	25	Yes	Yes	Yes	Supply off, exhaust blocked by paper, window open, white board
226	972	80	37	18	Yes	Yes	Yes	Exhaust blocked by map, window open, plant, white board

*** ppm = parts per million parts of air**
CT = ceiling tiles

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 4

Indoor Air Test Results – Lunenburg High School, Lunenburg, MA – May 3, 2001

Location	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
229	826	79	37	13	Yes	Yes	Yes	Window open
225	687	80	36	24	Yes	Yes	Yes	Window and door open
230	877	81	37	21	Yes	Yes	Yes	Exhaust blocked by desk
23	589	81	35	16	Yes	Yes	Yes	Exhaust blocked by file cabinet, door open, plant
Music Room	918	78	35	3	No	Yes	Yes	Supply and exhaust off
Music Room Office	1018	78	36	1	No	No	No	
234 Home Ec	514	79	38	0	Yes	Yes	Yes	Exhaust off, Dryer-hose disconnected, refrigerator, white board
102	565	81	34	19	Yes	Yes	Yes	Supply off, exhaust blocked by desk, window and door open, food containers
113	625	80	35	18	Yes	Yes	Yes	Supply blocked by desk, exhaust off, window and door open
112	620	80	36	19	Yes	Yes	Yes	Window open

*** ppm = parts per million parts of air**
CT = ceiling tiles

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 5

Indoor Air Test Results – Lunenburg High School, Lunenburg, MA – May 3, 2001

Location	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation Intake	Ventilation Exhaust	Remarks
111	579	79	37	2	Yes	Yes	Yes	Thermostat off, window and door open
110	653	80	39	13	Yes	Yes		
Graphics	975	74	46	10	No	Yes	No	Supply off, flammables, window mounted A/C-no filter
Photocopier Room	747	70	41	0	No	Yes	Yes	Supply and exhaust off, 3 photocopiers, (2) liquid toner
Graphics Computer Room	676	74	36	0	No	No	Yes	Wall mounted A/C-on, door open
Woodshop	563	82	38	0	No	Yes	Yes	Exhaust off, door open
224 Art Room	856	83	40	12	Yes	Yes	Yes	Exhaust off-blocked by tablecloth, window and door open, hexane, floor fan
223 Art Room	904	85	38	16	Yes	Yes	Yes	Door open
Cafeteria	660	83	34	15	Yes	Yes (3)	Yes	1 of 3 supply vents off

*** ppm = parts per million parts of air**
CT = ceiling tiles

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred 600 - 800 ppm = acceptable > 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%